Fluent CAPE-OPEN COM/CORBA Bridge and CO-Compliant Unit Operation

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Introduction

- DOE sponsored project October 2000 – December 2004
  - Fluent, NETL, ALSTOM Power, Aspen Tech, Intergraph, and West Virginia University
- Developed advanced power-plant simulation capability by integrating plant and equipment-level models
  - Aspen Plus (process simulation), FLUENT (CFD), proprietary design codes
- Fluent COM/CORBA bridge has been demonstrated to work with HYSYS. Tests with gPROMS in progress
- Won 2004 R&D 100 Award!
  - " … one of the 100 most technologically significant products introduced into the marketplace over the past year"

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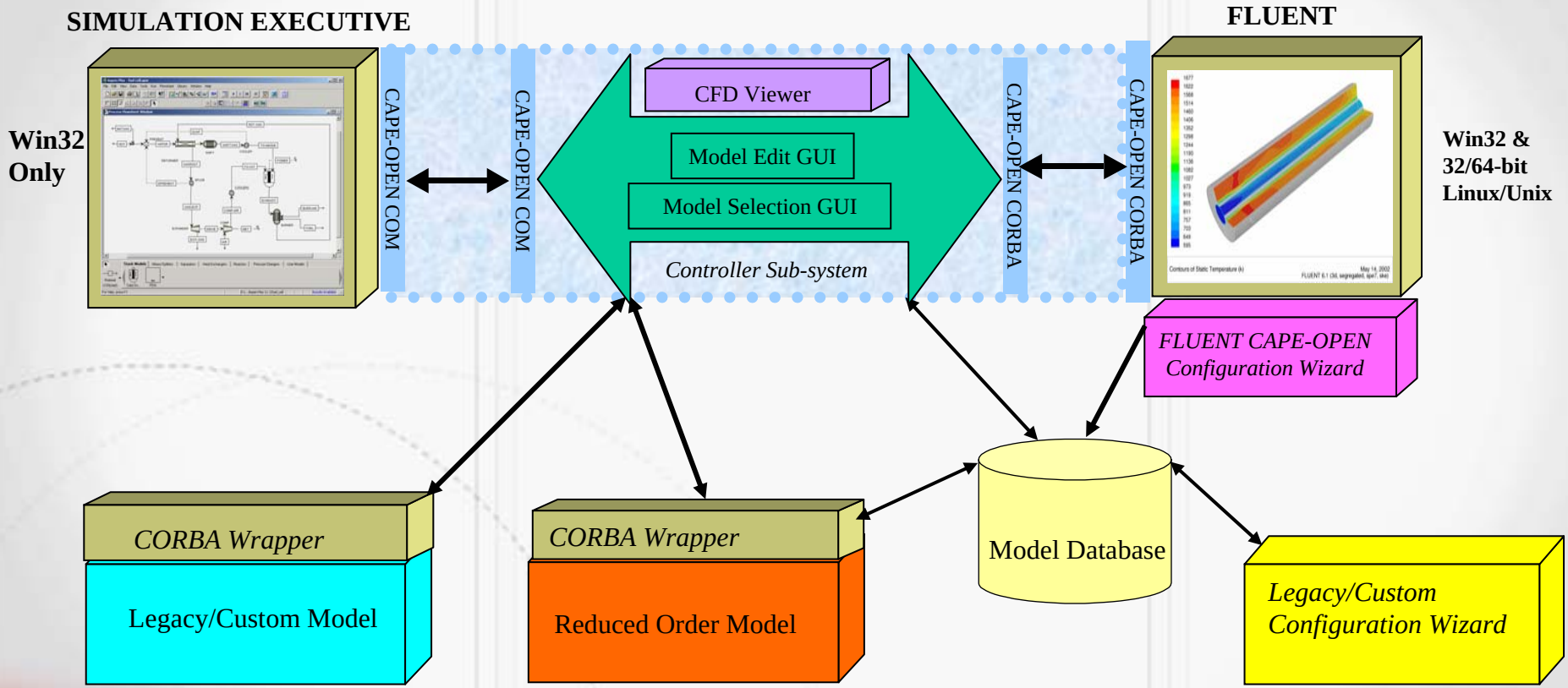
Fluent COM/CORBA Bridge - Architecture



Fluent COM-CORBA Bridge - Data Exchanged

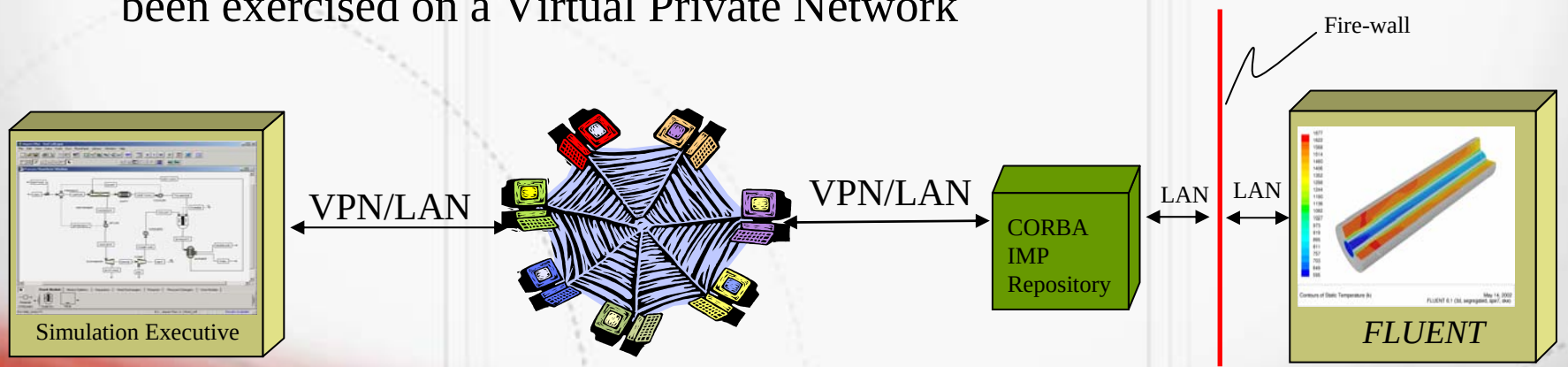
- From Aspen Plus (CO Process Simulator) to FLUENT
  - Chemical species specification
  - Constant properties: h_0, s_0, molecular weight
  - Physical properties (constant or as function of T): C_p, μ, ρ, k
  - Reaction stoichiometry and power-law parameters
  - User-defined CFD model parameters
  - Stream data at inlets: F, x, T, P
- From FLUENT to Aspen Plus (CO Process Simulator)
  - Stream data at outlets: F, x, T, P
  - Updated parameters CFD parameters

Fluent COM/CORBA Bridge – Remote Simulation

Aspen Plus running on Windows can exchange data with FLUENT running on Windows, Linux or Unix

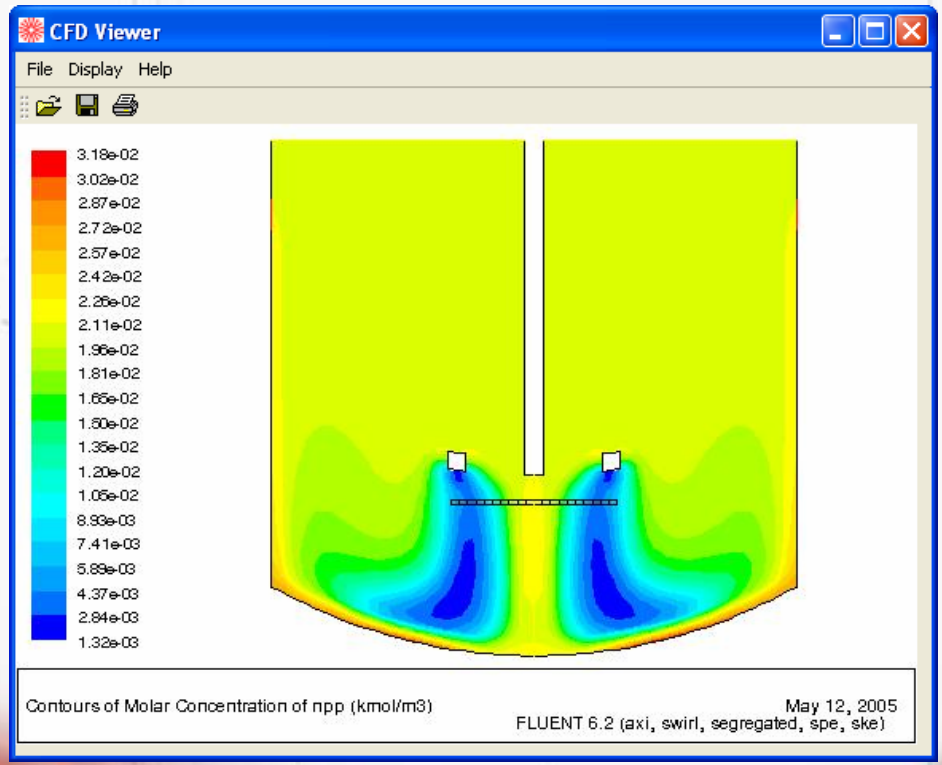
CORBA Implementation Repository is employed for cross-platform and cross-network communication via the Internet Inter-ORB Protocol (IIOP).

Cross-network communication and data transfer has only been exercised on a Virtual Private Network



Fluent COM/CORBA Bridge – CFD Viewer

CFD Viewer available in the process simulation environment to allow the process analyst to visualize the distribution of FLUENT calculated quantities, i.e., distribution of species molar concentration, temperature distribution within reactor, etc.



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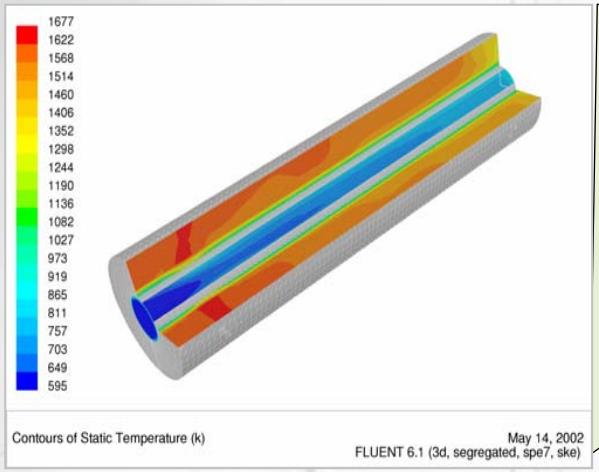
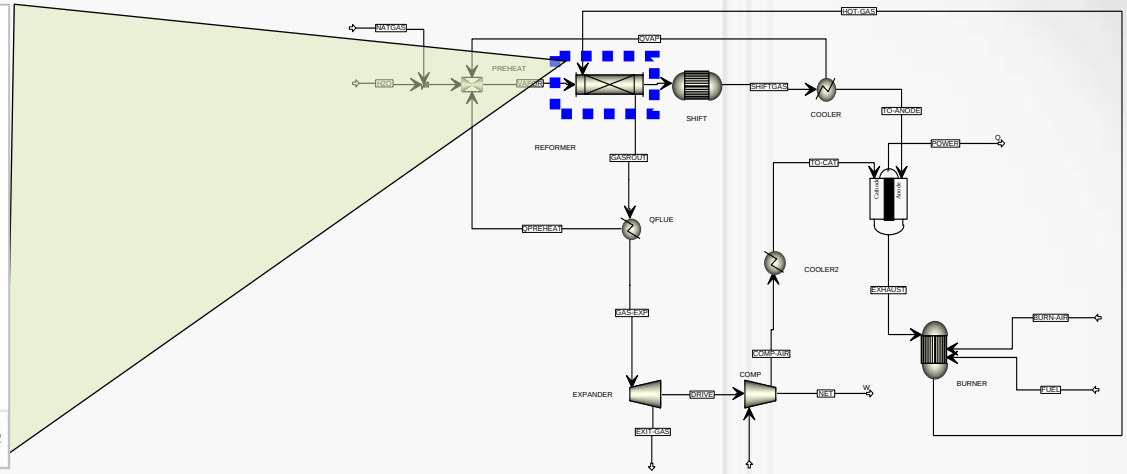
Integration Work Flow





CFD Analysis

- Develop CFD Model
- Configure CFD model for CO-compliance
- Add CFD Model to Database

Process Analysis

- Develop Process model
- Browse CFD Database and select model
- Enter CFD model parameters
- Set up solution strategy
- Map species names
- Conduct integrated simulation
- View CFD results

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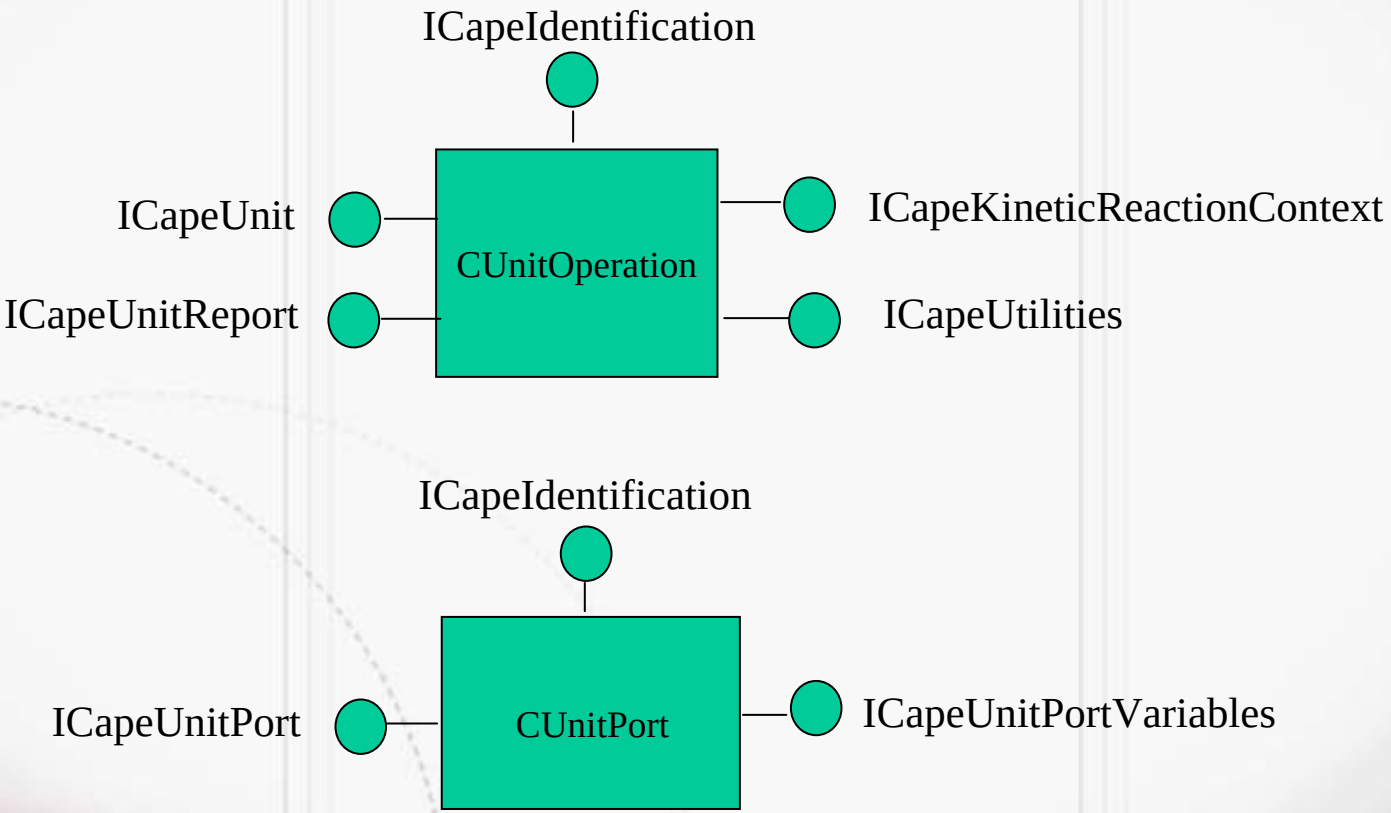
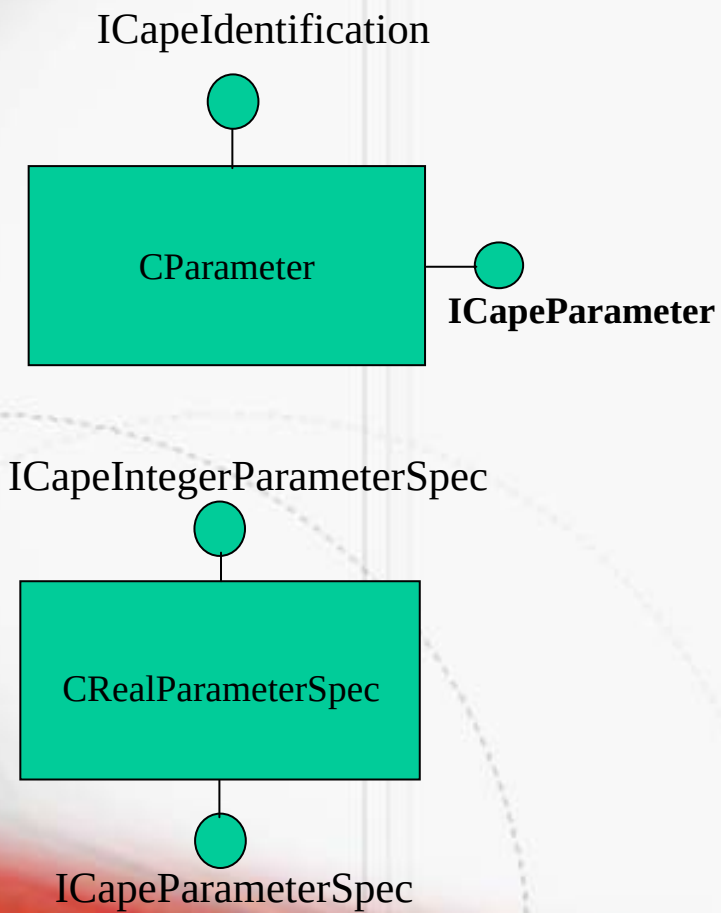
Implemented COM COCLASSES



Implemented COM COCLASSES – contd.



Suggested Implementation Guidelines

- Develop a test-harness that mimics the process simulator to test the implementation of the CO-compliant external unit operation model.

- The Initialize method should be called first by the Simulation Executive to carry out any necessary bootstrapping before allowing the user to invoke the Edit method

- The process simulator should not proceed right-away with executing the CO block after the user connects the material streams to the block – allow user to edit the block parameters, if needed, before calling the ICapeUnit::Calculate method

- The simulation executive should call the ICapeUnit::Validate method before calling the ICapeUnit::Calculate method for each CO block

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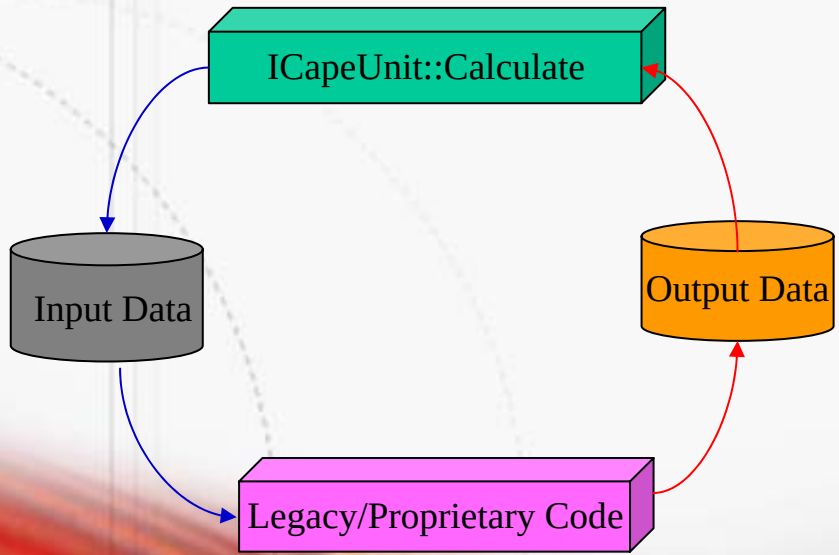
Suggested Implementation Guidelines

- Use of files for data exchange in a CO CORBA wrapper may well be a sensible “first-cut”, especially when hooking complicated legacy simulation codes written in languages such as Fortran, and where the expertise for mixed-language programming is lacking

- When using files within a CAPE-OPEN wrapper, the input/output files should be updated within the ICapeUnit::Calculate method



Suggested Implementation Guidelines

- The CO-compliant simulation executive should provide the options to step through the execution of the blocks as well as provide the means to run the coupled simulation “unattended” by simply clicking on a “Run” button

- Develop portable CO model configuration tools as a means to couple a unit operation model with the host process simulator via the Controller, i.e., use XML technology, along with a cross-platform scripting language such as Perl, Python or Scheme

- Avoid porting headache by using cross-platform CORBA library and GUI toolkits for the custom/proprietary wrapper development, i.e., ACE/TAO or JacORB middleware

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Suggested Implementation Guidelines

- Ensure mass conservation within the wrapper code – if the wrapper code generates mass through discrete phase injections, this should be reflected by introducing special (physical model port) material ports to the CO block on the flowsheet to account for the mass generation and/or destruction

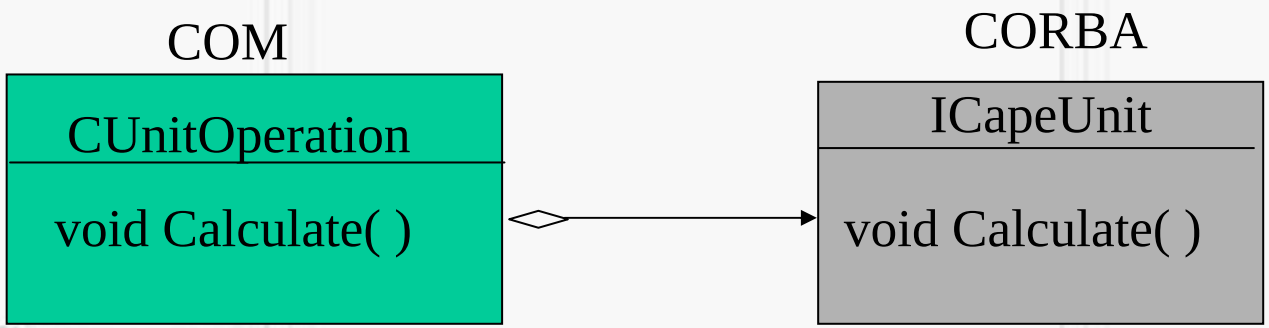
- Be prepared to develop workarounds. For example, species names in the process simulation executive may not match the species names in the proprietary/custom unit operation model

- Make the most of the interfaces that are defined in the Error module of the IDL specifications.

- Use the ICapeUnitReport interface to report convergence, fault conditions, etc from the collocated or remote unit operation

Suggested Implementation Guidelines

- Make ample use of software design patterns, i.e., Bridge Pattern, Factory, Singleton, Adapter, etc.



- Use bi-directional GIOP CORBA protocol as a means to avoid the known firewall issues with CORBA – this will ensure that the client port connection is also employed by the remote server to communicate with the client rather than trying to use a separate port connection

Suggested Implementation Guidelines

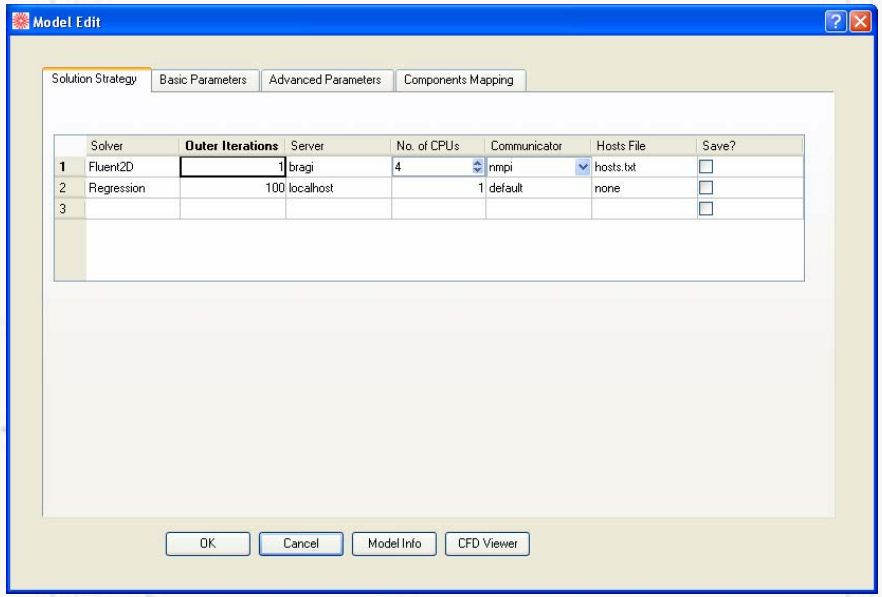
- Provide implementation support for the attributes of each CO parameter, i.e. lower and upper bounds, access mode type, etc. to avoid errors in the process simulator

- If using or interfacing with Microsoft .NET managed code, make sure you are comfortable with the intricacies of Runtime Callable Wrapper, COM Callable Wrapper, type library import, Global Assembly Cache, deployment issues, etc. to avoid frustrating debugging sessions

- For the CORBA unit operation, use a library that supports the common CORBA Services, especially for remote simulation, i.e., Property Service, Security Service, Naming Service or Trading Service or Implementation Repository Service

Suggested Implementation Guidelines

- Try to provide for the use of multiple “solvers” or Solution Strategy to simulate a CO-compliant model on the flowsheet



- Employ process and CFD simulation models that run smoothly in stand-alone mode to develop and test the implementation of the COM/CORBA bridge

Concluding Remarks

- Use of Microsoft native COM or .NET component technology is almost inevitable, if the intent is to develop a bridge from a process simulator to an external unit operation model – the most widely-used process simulators only run on Windows using COM technology, with very little support for Linux/Unix platforms

- Implementing external unit operations using COM or .NET technology is not recommended since these technologies are not readily portable to the Linux/Unix platforms.

- The design of ICapeUnitReport interface should be reviewed to allow for more straightforward transfer of image report type using the CORBA octet data type.

Thank you for listening!